Parabolic Trough Technology
State of the Art and New Developments

Dipl.-Ing. Klaus Hennecke
DLR Institute of Solar Research

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Summary

State of the Art Collector

Technical Data

Module:

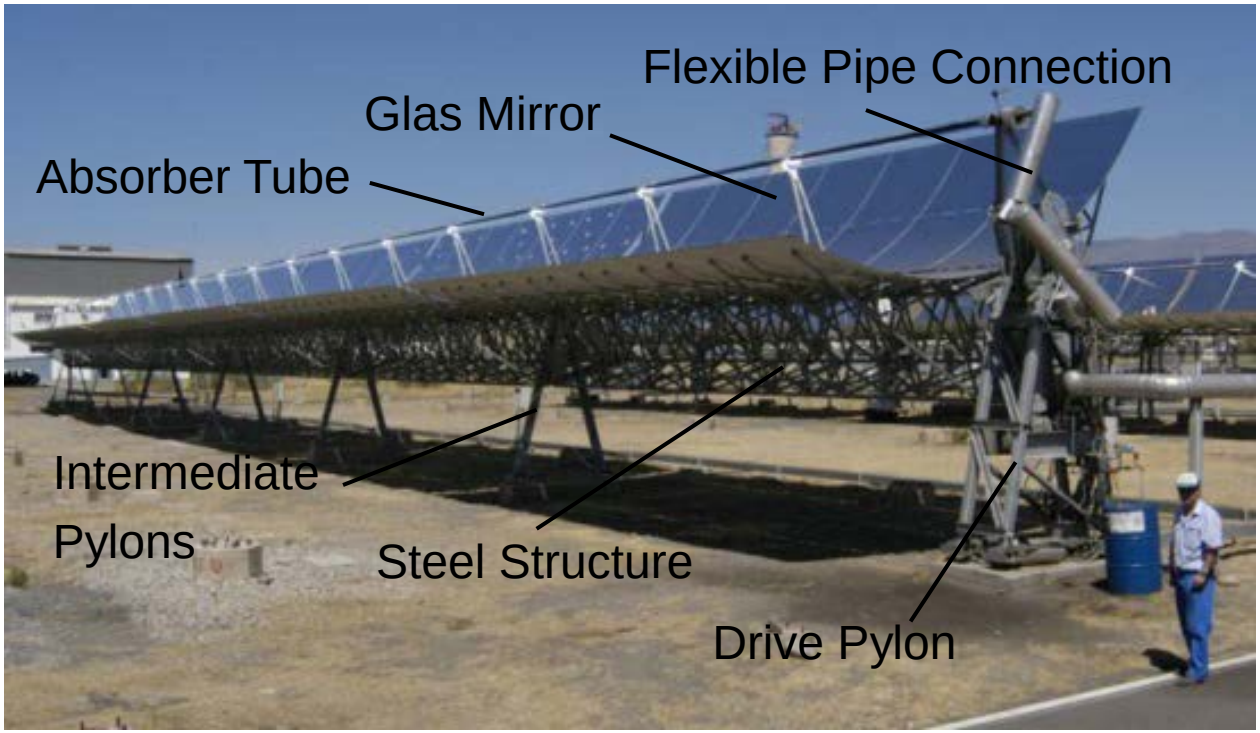
- 5,77 m x 12 m

Collector:

- 12 Modules
- 830 m²

Focal Length:

- 1,71 m



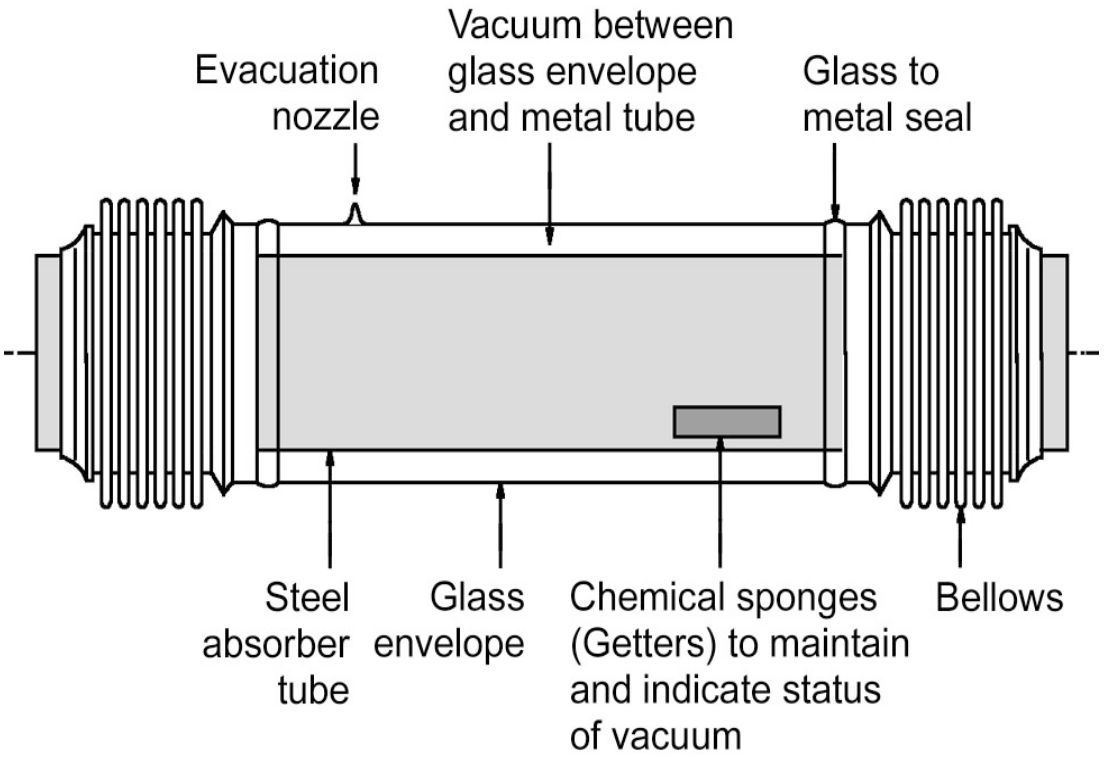
Collector Structure Development

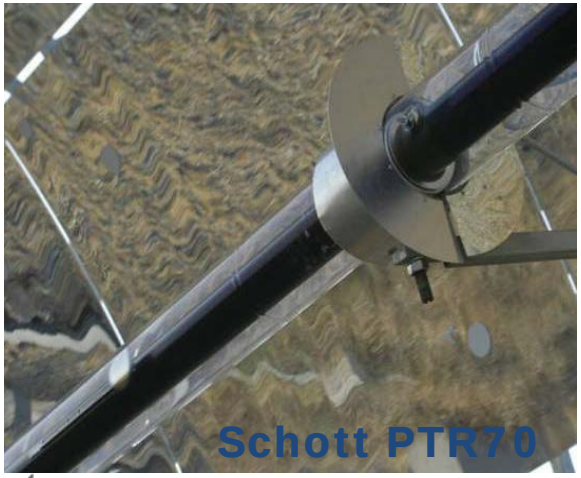
	LS-1	LS-2	LS-3	Euro-trough	Helio-trough	Sener-trough 1	Sener-trough 2	Ultimate Trough
Start of development	1984	1985	1989	1998	2005	2005	2006	2009
Aperture width in m	2,55	5	5,77	5,77	6,78	5,77	6,87	7,51
Length per Module/SCE in m	6,3	8	12	12	19	12,27	13,23	24
SCA length in m	50,2	47,1	99	147,8	191	-	158,8	242,2
Focal length in m	0,68	1,40	1,71	1,71	1,71	1,71	2	-
Torsion force carried by	Torque tube	Torque tube	V-truss Frame-work	Torque box	Torque tube	Torque tube	Torque tube	Torque box

Key Component: Receiver Tube
Heat Collecting Element HCE

Receiver Technology

- L = 4060 mm
- D = 70 mm (80, 90, ...)
- Glass d = 125 mm
- Solar Transmittance: 97%
- Solar Absorptance: 96%
- Thermal Emittance: < 10%
- Vacuum: 10^{-3} mbar
- Overall Heat Loss: < 250 W/m





Solar Field Construction – Civil Works and Pylons

Collector Assembly – Steel Structures and Mounting Jigs






Solar Field Installation



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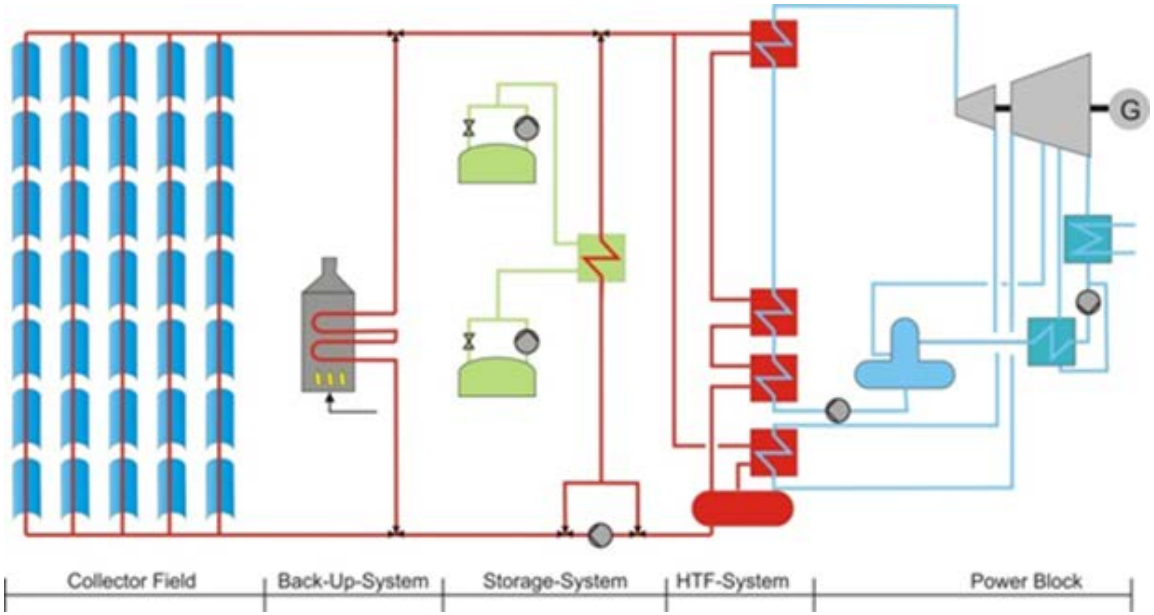
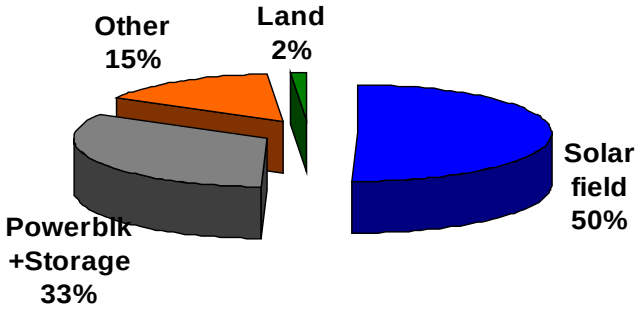
Parabolic trough power plant characteristics

Typical data (approx. Values)
- Thermal oil circuit operating Temperature:
  400 ° C
- Nominal Power:
  50 – 300 MW
- Solar field size:
  500.000 – 2,5 Mio m²
- Molten salt storage capacity:
  0 – 10 full load hours
- Fossil fired Back-up heater
- Annual full load hours:
  2.000 - 5.000 h/a

Solar thermal power plants provide flexible and predictable power on demand



- Total Investment:
  2.200 - 5.000 €/kW
- Power Block:
  1.000 €/kW
- Solar field:
  200 - 400 €/m²



Cost structure

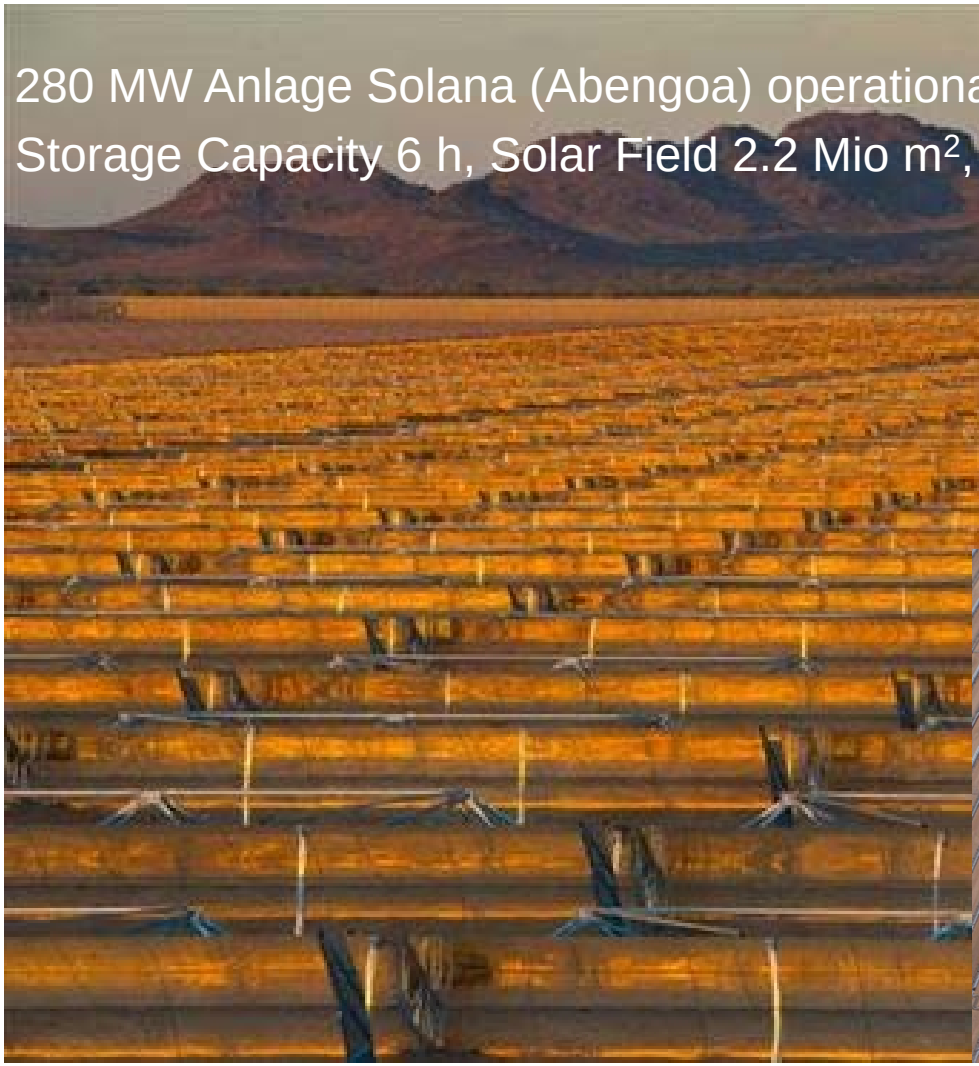
Andasol 1, 2, 3 Guadix, Spain
3x 50 MW, 3700 Full Load Hours

Parabolic Trough: Commercial Technology

Economies of Scale

280 MW Anlage Solana (Abengoa) operational since 2013

Storage Capacity 6 h, Solar Field 2.2 Mio m^2, Production 980 GWh/a



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Quo Vadis?

Mature – No more R&D required?

How was this achieved?

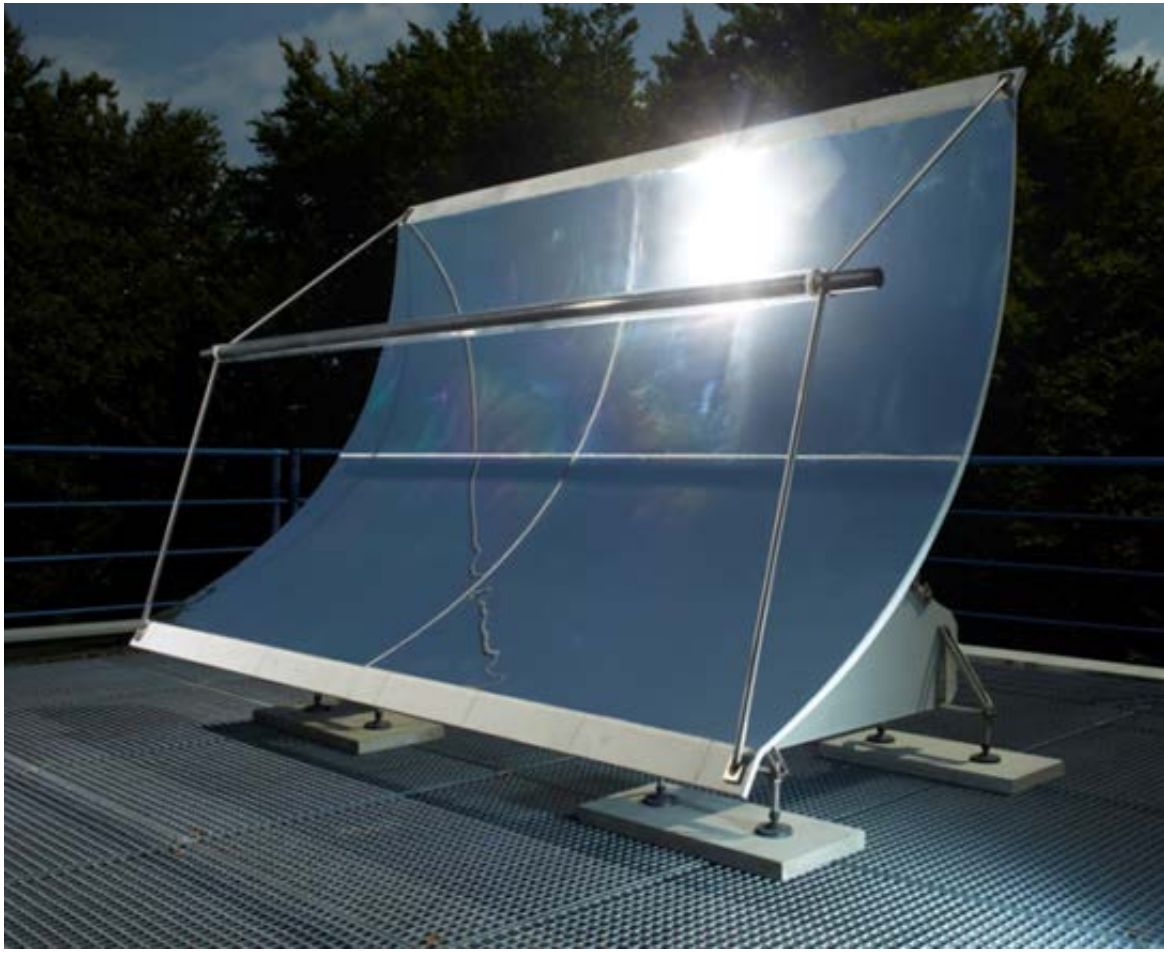
- Economies of scale
- Technologie changes
- New materials

Air travel

- 70 years ago: Luxury for few
- Today: Normality for (almost) everybody

New Developments: Alternative Materials

Concrete Structure
+ Precasting Technology
+ Low Material Cost
+ Low Labour Cost
+ High Local added Value
+ High Weight
- Manufacturing Tolerances
- Surface Quality
- Suspension and Tracking
- Site Logistics



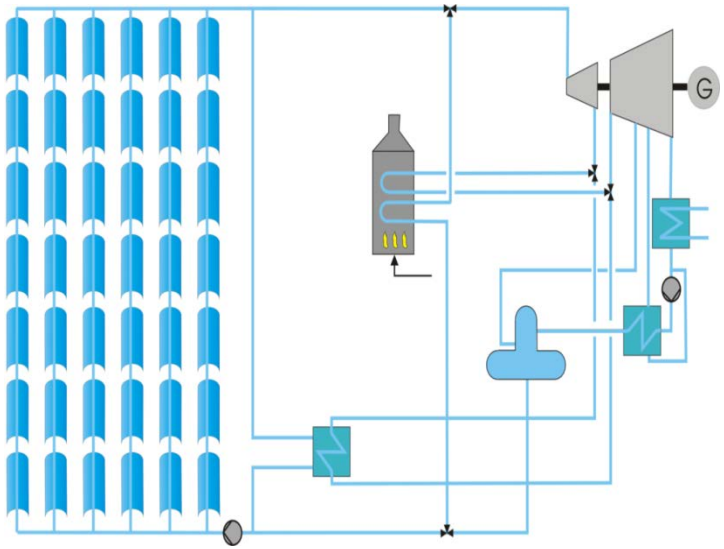
Direct solar steam generation

Advantages:

+ Increased Temperature
  + improved performance
+ No secundary circuit:
  + reduced investment
  + reduced losses
+ non-toxic, non-inflammable medium

Challenges:

- Two-phase Flow
- Temperature gradients
- Increased operating pressure
- No cost effective storage yet



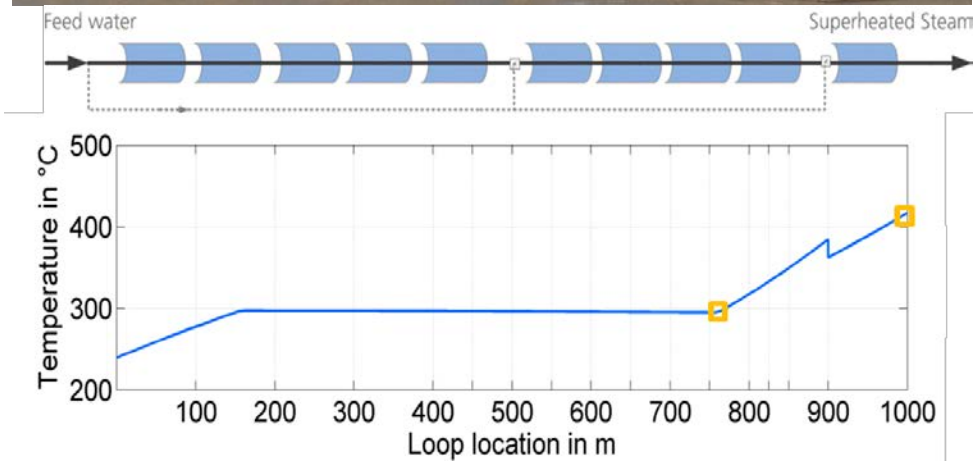
Solarlite Kanchanaburi (TSE 1)

- Industry partner: Solarlite
- 5 MW parabolic trough plant with direct steam generation (30 bar, 330° C)
- Recirculation Process
- Location: Thailand
- Operational since 11/2012

New Development: Once Through Process

DLR – CIEMAT Co-operation

- Extension of the DISS-testfacility on the Plataforma Solar de Almería
- Successfull demonstration of safe operation under transients
  - Live steam temperature
  - Dry-out point
- Next step: Improved performance based on local DNI prediction



New Development:Molten salt as heat transfer medium

Advantages:

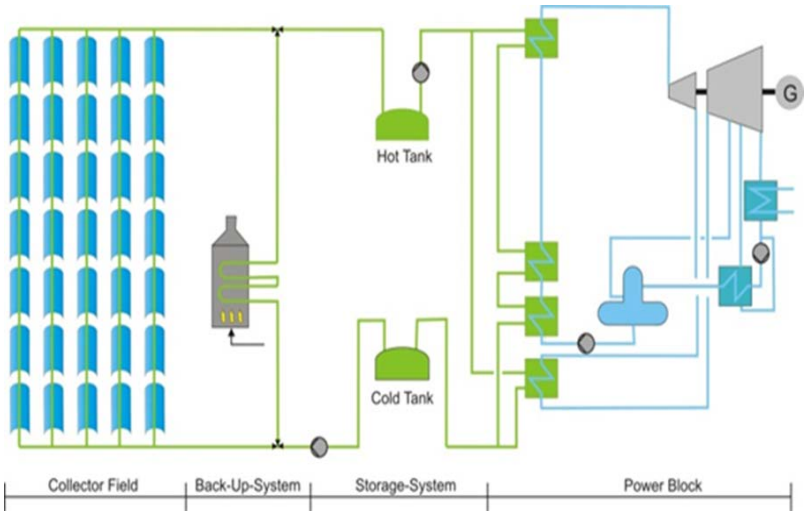
+ Increased temperature
+ Direct Storage
+ Increased storage capacity
+ low-cost medium for heat transfer storage
+ not hazardous to water

Challenges:

- High melting point
- Freeze protection / trace heating
- Procedures for filling, draining, malfunctions
- Corrosion / Material selection
- Long term stability

Current research effort:

Completion and operation of Évora Molten Salt Platform to demonstrate solutions to the challenges



Summary and Conclusions

- Parabolic troughs are regarded a mature technology and are the most widely applied CSP technology in the present early markets

- Developments to improve their competetiveness build on:
  - Economies of scale
  - New materials
  - Increased Operating Temperatures

- Success factors for the future:
  - Stable framework for market and technology development
  - Continuous feedback from operation into research
  - Close co-operation between industries and research